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ABSTRACT

Reported is a study to determine the effect of planetarium instruction in terms of immediate attainment, attitude, and retention in the teaching of selected celestial motion and non-celestial motion concepts, when contrasted to or combined with the inquiry activities utilized by the nationally developed science curricula. Observations were made on three treatment groups at both the junior high school and college levels. One hundred eighth-grade students in a school system in New York participated in the study which was replicated at Edinboro State College, Pennsylvania. Investigator-developed instruments were administered six weeks after the treatment to measure retention. An astronomy related semantic differential instrument was designed to measure student perceptions concerning the unit of instruction and astronomy in society. Results indicated that: (1) the group (Treatment Group I) which experienced the orientation session did significantly better on content learning than the group which did not; (2) the combined treatment group (III) was the only group which significantly benefited from the treatment; (3) all groups showed minimal loss of content achievement on the retention test; (4) no interaction effect between treatment and retention was noticed on posttest data for the college treatment groups; and (5) the planetarium group (I) in both junior high and college studies had the greatest positive perception change. (Author/PEB)

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A STUDY OF PLANETARIUM EFFECTIVENESS ON STUDENT ACHIEVEMENT, PERCEPTIONS AND RETENTION

by

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Claims of the Planetarium's Effectiveness

Numerous articles have been written which indicate that the planetarium is a supurb tool for instruction and that it imparts an excellent understanding of the conceptual basis of astronomy. Morris and Peterson (1972), writing about how the planetarium can best be brought to the students, state:

> "....planetariums take science out of the realm of the abstract, bringing it clearly and enjoyably to life. Astronomy and space science become relevant especially with the planetarium's ability to simulate most celestial phenomena....the planetarium is a powerful motivator."

Steinbaum (1968), referring to the importance of the teachers chosen to direct the planetarium, states:

> "....the skillfully used planetarium is a supurb tool for teaching. It can impart to the learner, whether child or adult, an excellent idea of the conceptual basis of astronomy."

Statements such as the above are typical of the claims that educators have made regarding the planetarium facility. These statements, however, are based upon intuitive feelings and not on research findings. The bulk of the planetarium research deals with the managerial aspects of running such a facility.

Research studies have been conducted which attempt to evaluate the effectiveness of the planetarium as an instructional device. In general, these studies conclude that the planetarium is less effective than classroom instruction in the teaching of specific astronomy concepts. All the major research studies brought the students into the planetarium and taught them specific content objectives. This planetarium group was then compared to a classroom group taught the same content objectives. At no time was an orientation to the functions of the planetarium facility given to the group instructed in the planetarium. Planetarium operators have indicated the

necessity of an orientation session or sessions before a meaningful lesson can be taught. One must overcome any "mystique effect" which may be present before instruction can be successful.

Previous studies have failed to provide controls for teacher effectiveness as a variable in one teaching situation, the classroom, over another, the planetarium. Campbell (1963) indicated that the consistency of instructional quality in any comparative treatment is a variable which must be controlled when attempting to determine the influence of various means of instruction. (See Tables 1 - 3).

Formal Statement of the Problem

The purpose of the study is to determine the effect of the planetarium in terms of immediate attainment, attitude and retention in the teaching of selected celestial motion and non-celestial motion concepts, when contrasted to or combined with the inquiry activities utilized by the nationally developed science curriculums.

Significance of the Study

Moore (1966) indicated that the planetarium facility is the most complex visual instructional device that the teacher can employ. However, research into the effectiveness of the planetarium has been surprisingly meager and the few studies which have been conducted generally indicated that the planetarium is not significantly more successful in the teaching of selected concepts than classroom methods. If these research findings are accurate, then it would appear that the installation and operation of over one thousand facilities in the United States has been a mistake. These research findings question the creditability of what educators have professed about the planetariums. Further, if the most advanced audio-visual device in today's schools is ineffective

as a means of instruction, this should be considered in planning for further technological advances.

The Pilot Study

The planetarium mystique effect, if existent, would be an important variable to consider when researching planetarium instructional effectiveness. A pilot study was conducted early in the research to establish the existence of a mystique effect and to determine if an orientation session prior to instruction is effective in minimizing this effect.

Two comparable groups of students were administered the Daily Motion Concept Test (Forms A&B) as a pretest to measure entering knowledge of the content objectives. One group was given an orientation session intended to familiarize students with the construction and operation of a planetarium. During this session three aspects of the facility were discussed; the purpose of the dome ceiling, the function of the major components of the projection equipment and the purpose of the red lighting system. These were the only areas discussed during this session. The following day both groups received a planetarium experience dealing with diurnal motion. Tape recordings were employed with the researcher operating the projection devices. The Daily Motion Concept Test was again administered and changes in content achievement scores were analyzed to determine the relative effectiveness of the orientation session on content achievement.

Experimental Design

Is the planetarium an effective instructional device for teaching selected astronomy concepts when contrasted to or combined with inquiry activities used in the nationally developed science curriculums? In order to examine this

question a pretest-posttest measure with three groups is desirable. The design used in this study is the Combined Multiple Time-Series, Pretest-Posttest Three Group Design as described by Stanley and Campbell.

Experimental Procedure

Observations were made on three treatment groups at both the junior high school and college levels. Treatment Group I received the planetarium instruction consisting of one orientation session, three sessions dealing with concepts of celestial motion and two sessions dealing with concepts of non-celestial motion, i.e., time zones and the earth coordinate system. Group II received five sessions of instruction dealing with the same concepts as in Group I but through activity inquiries drawn from nationally prominent curriculum projects. Group III experienced combined sessions of Groups I and II with concepts randomly assigned to the planetarium or classroom inquiry activities. Group III was established to determine if dimensions of retention, attitude and content achievement exist that can be reinforced by either treatments I and II.

Population

The study was conducted using half the eighth grade students (N=100) from the Pine Grove Middle School of the East Syracuse-Minoa School System. Students at this school are randomly assigned to one of two teams, then randomly assigned to classes.

The study was replicated at the Edinboro State College of Pennsylvania during the first two weeks of the fall semester. The purpose of the Edinboro study was to determine differences that may exist in content achievement, retention and perceptions at various educational levels.

Orientation Session Results:

Table 4 shows pre and posttest data for the treatment groups administered the Daily Motion Concept Test. Used as a pretest and a posttest this test was used to determine content knowledge of daily motion. Treatment I (the control group) had the instructional session in the planetarium. Treatment II had an orientation session prior to the instructional session.

Table 5 shows the computed values of t obs. and the f approximation for the pretest data.

Table 6 shows the computed values of t obs. and the f approximation for the posttest data.

Content Knowledge Pretest Results:

Table 7 summarizes the results of the pretest scores for both the college and junior high school treatment groups. An analysis of variance was performed on both the college and junior high school test results to test the hypothesis of no significant differences in entering knowledge. The analysis of variance for the junior high school treatment groups is summarized in Table 8 . As a preliminary test for homogeneity of variance an F max. statistic was determined.

The analysis of variance for the college treatment groups is summarized in Table 9 .

Posttest Results:

Table 10 summarizes the results of the posttest scores for the junior high school treatment groups.

An analysis of covariance was performed on the posttest scores using the pretest as a covariate.

Table 11 shows the analysis summary table for the junior high school posttest scores. The adjusted means for the treatment groups are also shown in this table.

Table 12 shows the analysis of covariance summary table for the junior high school retention test scores. The adjusted means for the treatment groups are also shown in this table.

Table 13 summarizes the results of the posttest results for the college treatment groups.

As the analysis of pretest results indicated no significant differences between treatment groups, a 2 x 3 factorial experiment was performed in order to permit the evaluation of a possible interaction effect of treatments and posttests. The levels of factor A represented the two posttest measures and the levels of factor B represented the three treatment groups.

Table 14 summarizes the two-way analysis of variance. The data support the null hypothesis that the main effects of factor B are zero. Inspection of the profiles in Fig. 1 of the simple effects of factor B for levels a_1 and a_2 indicate the lack of interaction.

The college posttest and retention scores were factored into their component concepts to determine if celestial motion concepts were better taught by one treatment than non-motion concepts. None of the observed F ratios were significant at the .05 level. Inspection of the simple effect profiles in Fig. 2 indicates the difference in growth of the combined treatment group.

Analysis of the Astronomy Perception Test Scores:

Table 15 summarizes the pre-post results of the factor analyses of the semantic differential data for each of the five concepts in the Junior High School

and College studies.

Figs. 3 & 4 illustrate treatment changes from pretest to posttest. Adjusted factor score (standard scores) changes are shown for the combined five concepts.

TABLE 1

EXPERIMENTAL CONDITIONS or DESIGN

	Control Group Comparisons			Controls for Covariates		Orientation to Planetar.	Cognitive Objectives Assessed	Affective Objectives Assessed
	Random Design		Non-Random Design	Pretest	Others			
	By Class	By Student						
SMITH	✓						✓	
ROSENBERGY	✓				✓		✓	
WRIGHT	✓						✓	
REED		✓					✓	✓
RIDKY		✓		✓		✓	✓	✓

TABLE 2

EXPERIMENTAL CONDITIONS or DESIGN

	Retention Assessed	Treatment Time (Sessions)			Experimental Controls			Treatment Groups		
		1	2-5	5+	Teacher Effectiveness	Consistency of Instruc.		Planetarium	Classroom	Combined
						Planet.	Class			
SMITH		✓						✓	✓	
ROSEMERGY			✓					✓	✓	
WRIGHT		✓				✓		✓	✓	
REED	✓	✓						✓	✓	
RILKY	✓			✓	✓	✓	✓	✓	✓	✓

TABLE 3

EXPERIMENTAL CONDITIONS or DESIGN

	Outcomes Favoring			Level on Which Study Conducted			
	Planetarium	Classroom	Combined	Elem.	Junior High (7-8)	High School (9-12)	College
SMITH		+	o	✓			
ROSEMERGY		+	o	✓			
WRIGHT	+		o		✓		
REED		+	o				✓
RIDKY					✓		✓

TABLE 4

Pre and Posttest Group Data

Sample Size	N= 26	N= 20	Pretest
Sample Mean	x= 5.27	x= 4.65	
Sample Variance	S= 2.66	S= 2.13	
Sample Size	N= 26	N= 20	Posttest
Sample Mean	x= 7.88	x= 9.25	
Sample Variance	S= 7.18	S= 7.09	

TABLE 5

t obs. = 1.356

f = 52.25

TABLE 6

t obs. = 1.719

f = 43.68

TABLE 7

CONTENT KNOWLEDGE PRETEST DATA

Group	N	Mean	Std. Dev.	
planetarium	47	8.94	3.25	Junior High School
classroom	23	7.91	2.15	
combined	26	11.27	2.49	
planetarium	25	13.20	3.09	College
classroom	21	13.43	3.27	
combined	25	14.00	2.73	

TABLE 8

ANALYSIS OF VARIANCE OF CONTENT PRETESTS

Source of variation	SS	df	MS	F
Between Groups	162.60	2	81.30	9.766
Within Groups	674.35	93	8.35	
Total	836.95			

TABLE 9

ANALYSIS OF VARIANCE OF CONTENT PRETESTS

Source of variation	SS	df	MS	F
Between Groups	8.44	2	4.22	0.442
Within Groups	649.14	68	9.546	
Total	657.58			

TABLE 10

POSTTEST GROUP DATA

Group	N	Mean	Std. Dev.	
planetarium	43	9.09	3.41	
classroom	23	7.61	2.53	Posttest
combined	28	14.14	3.11	
planetarium	40	9.00	3.13	
classroom	21	7.67	2.86	Retention
combined	27	13.96	3.38	

TABLE 11

ANALYSIS OF COVARIANCE SUMMARY TABLE

Source	SS	df	MS	F
treatment (Between)	282.70	?	141.35	17.05
error (Within)	704.64	85	8.29	
Total	987.34	87		

treatment group	treatment mean	adjusted mean
Combined	14.44	13.40
planetarium	9.09	9.32
classroom	7.76	8.54

TABLE 12

ANALYSIS OF COVARIANCE SUMMARY TABLE

Source	SS	df	MS	F
treatment (Between)	304.06	2	152.03	15.07
error (Within)	777.06	77	10.09	
Total	1081.13	79		

treatment group	treatment mean	adjusted mean
Combined	13.88	13.33
planetarium	8.95	9.04
classroom	7.61	8.18

TABLE 13

COLLEGE POSTTEST DATA

Group	N	Mean	Std. Dev.	
planetarium	19	14.00	2.57	
classroom	17	14.06	2.92	Posttest
combined	21	15.00	2.93	
planetarium	20	14.65	3.57	
classroom	15	14.60	3.38	Retention
combined	18	16.11	2.49	

TABLE 14

TWO WAY ANALYSIS OF VARIANCE SUMMARY TABLE

Source	df	MS	F-ratio
A posttest-retention test intervals	1	16.00	1.68
B treatments	2	18.22	1.92
AB tests by treatments	2	0.83	0.0874
Error (within cells)	104	9.51	-

TABLE 15

SUMMARY OF FACTOR ANALYSES--FIVE CONCEPTS, POOLED GROUPS

Junior High School (pretest)			(posttest)	
Concept	number of factors	total % variance acct'd for	number of factors	total % variance acct'd for
1	6	60.58	6	65.19
2	6	62.53	6	69.20
3	5	62.91	5	63.86
4	6	67.81	4	59.12
5	4	66.09	3	60.49
College (pretest)			(posttest)	
Concept	number of factors	total % variance acct'd for	number of factors	total % variance acct'd for
1	6	67.43	5	65.74
2	6	70.73	5	64.92
3	6	73.45	4	65.36
4	5	69.40	5	70.93
5	4	72.57	4	74.43

FIGURE 1

SIMPLE EFFECTS

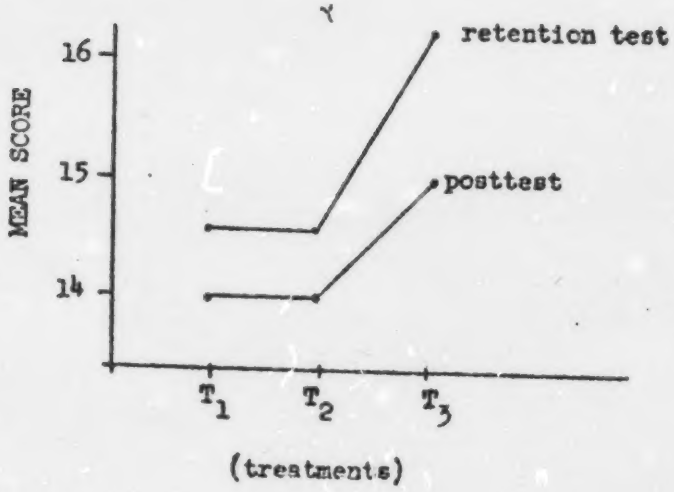


FIGURE 2

Simple Effects

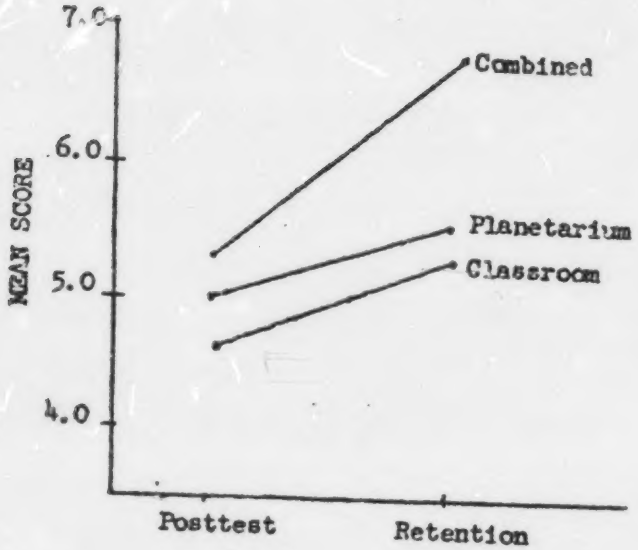


FIGURE 3

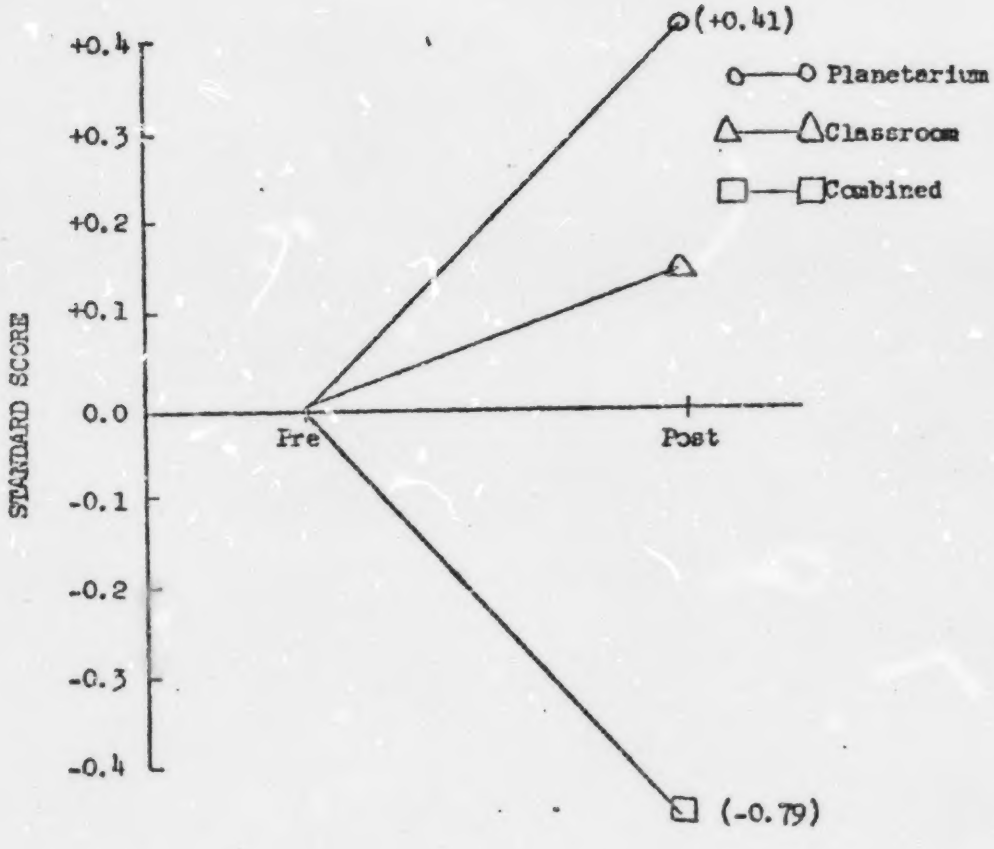
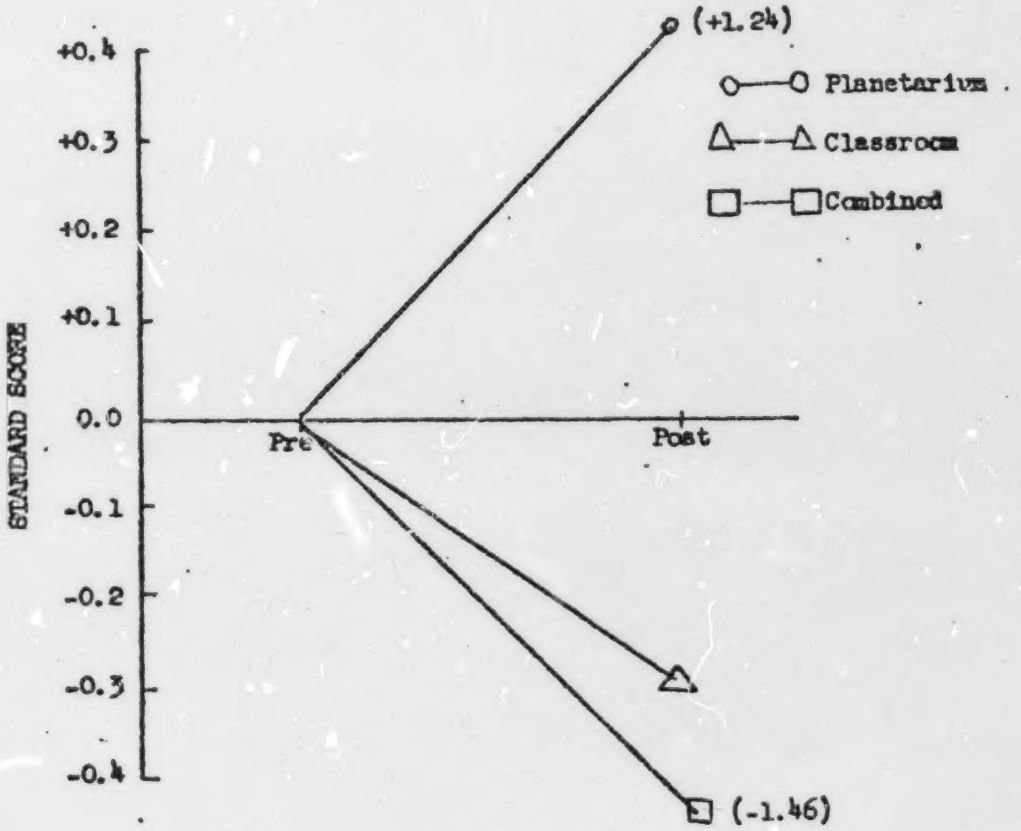

(+0.41)
Planetarium
Classroom
Combined
+0.4
+0.3
+0.2
+0.1
0.0
-0.1
-0.2
-0.3
-0.4
STANDARD SCORE
Pre
Post
(-0.79)

FIGURE 4


(+1.24)
Planetarium
Classroom
Combined
+0.4
+0.3
+0.2
+0.1
0.0
-0.1
-0.2
-0.3
-0.4
STANDARD SCORE
Pre
Post
(-1.46)

SUMMARY AND IMPLICATIONS

The conclusions to the Student's t distribution with the Welch approximation is that the group which experienced the orientation session did significantly better than the group which did not. An omega squared statistic indicated that there was a strong association in this difference. This finding is in agreement with what planetarium operators have eluded to. The study does not attempt to isolate the particular cause for the effect, but rather attempts to determine if the effect exists and whether it can be minimized.

The implication to be drawn from this segment of the study is that if a planetarium experience is contemplated the teacher needs to provide for an orientation session or schedule a number of sessions in the planetarium before instructional objectives can successfully be taught. This is in direct contrast to current planetarium useage.

Using the pretest data as a covariate, the combined treatment group was the only group which significantly benefitted from the treatment. The planetarium group showed a slight increase in achievement and the classroom group showed a decrease in content achievement. The decrease in achievement of the classroom group may be attributed to an experimentally induced difference. Similar analysis of the retention test, administered six weeks after the completion of the unit, indicated a minimal loss of all groups in content achievement as well as the maintenance of the significantly greater combined treatment group criterion score.

These findings suggest that at the junior high school level a combined teaching approach utilizing student centered activities in conjunction with planetarium experiences is more effective than the exclusive use of either teaching procedure.

Analysis of the overall posttest scores indicates that there was no interaction effect between treatment and retention for the college treatment groups. No treatment was more effective in the immediate attainment or retention of content objectives. All treatment groups achieved equally well.

The semantic differential concepts used were grouped into two broad categories; those related to their future participation in astronomy and those related to parts of the instructional unit. Scores on this instrument were factor analyzed and factor loadings obtained using the varimax rotation procedure. The overall perception change for all concepts showed that the planetarium group in both the junior high school and college studies had the greatest positive perception. The combined group in both cases had a negative standard score change. The junior high school classroom group had a slight positive standard score change while the college group had a negative standard score change.

It can be concluded from this study that the effectiveness of the planetarium appears not to lie in facilitating content achievement, but rather in effecting attitudinal change. Student experiences in the planetarium should take into account the ability of the facility to positively change student perceptions or attitudes. These findings further suggest that it would be of greater benefit to develop planetarium experiences that deal primarily in the affective domain.